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Jane Charles
Technological University Dublin, jane.charles@tudublin.ie

Derry Fitzgerald
Technological University Dublin, derry.fitzgerald@tudublin.ie

Eugene Coyle
Technological University Dublin, Eugene.Coyle@tudublin.ie

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Jane Charles[*] Derry Fitzgerald[†]

Eugene Coyle[‡]

[*]Dublin Institute of Technology, jane.charles@dit.ie

[†]Dublin Institute of Technology, derry.fitzgerald@dit.ie

[‡]Dublin Institute of Technology, Eugene.Coyle@dit.ie

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Development of a Computer Based Violin Teaching Aid, ViTool

Jane A. Charles[1], Derry Fitzgerald[2], Eugene Coyle[1]

[1] Dublin Institute of Technology, Dublin, Ireland
jane.charles@dit.ie, eugene.coyle@dit.ie

[2] Derry Fitzgerald, Cork Institute of Technology, Cork, Ireland
derry.fitzgerald@cit.ie

ABSTRACT

This paper considers the development of a violin teaching aid, called ViTool, which is based on violin pedagogy, sound analysis, and comparison of beginner and good player recordings. It is a computer based teaching aid and will ultimately consist of at least four task dependent tools. Typical beginner faults have been identified and features, that best describe them for classification purposes, are considered. The ViTool is not intended as a replacement or electronic teacher, but as a teaching aid. Presently, it seems that no such violin learning aid or tool exists and an opportunity exists for the development of such home learning aids. This paper puts forward the initial steps towards such a teaching aid.

1. INTRODUCTION

A possible approach for developing a violin teaching aid based on violin pedagogy, sound analysis and comparison of beginner and good player recordings was put forward in [1]. This teaching aid, which is called ViTool, is targeted at students who have difficulty listening attentively to the sounds they produce. It aims to draw their attention to the sound of a fault, offer correction and to train the user's ear to actively listen. The ViTool can be thought of as a type of 'box' which records a beginner, analyses it and returns a critique of the player's technique. The 'box' will have a priori knowledge of the piece and is also based on the standard tuning of A440. The ViTool will involve tuning the violin and the selection of the piece of music by the player. Then the recording will be made, analyzed and feedback will be offered to the player. The ViTool can be thought of as several task specific tools. This way, the needs of a beginner are better fulfilled. The ViTool could also be expanded and developed for higher level players who may need to work on a specific bow stroke or vibrato speeds. The approach could also be modified and applied to other stringed instruments.

1.1. Existing Systems

With current advances in signal processing and interactive computing, much more sophisticated systems and learning aids are now being developed. Hämäläinen *et al.* developed a successful real-time singing aid in [2], which describes the use of pitch-based, i.e. intonation, control of a game character by the user's voice. However a direct transfer of this approach into a violin, or another instrument aid wouldn't be as successful. A singer is physically 'free' to concentrate on a screen and able to react to it. Instrumentalists, especially beginners, need to be looking at what they are doing and looking elsewhere, i.e. at a screen, will disturb their position. For this reason, a system which offers feedback after the user has played their short piece would be much more effective. This differs greatly in approach to the Music Minus One [6] CDs which offer a variety of recordings to which the user plays the solo part.

1.1.1. Violin Technique and Sound Quality

The highly subjective topic of timbre and how it relates to violin technique cannot be avoided. No two people hear a sound exactly the same and so this research is biased in favour of what professional standard violinists seek in a violin sound. A good sound is produced through a combination of a naturally good sounding instrument plus an essentially flawless or highly efficient playing technique. The poorer the quality of the instrument, the greater the need for stronger or better playing technique. A better quality instrument allows the player to push their technique further. The relationship between timbre and technique has been explored and five main beginner faults have been determined [1]. These faults are visible in both the waveforms and the spectrograms. Briefly, the tone fault categories are onsets, offsets, amplitude, unevenness and asymmetry about the x-axis which may contain undesirable sounds such as squeaks, crunches, skating and nervousness.

Bow Stroke

The first bow stroke a beginner must master is called *legato*, which literally means 'tied together' or smoothly connected [4]. Mastering this ensures enough bow control upon which the student can develop other bow strokes, such as *staccato*. Initially the ViTool will be based on developing the legato bow stroke. Since the style or type of bow stroke used effects the readings obtained, only good player *legato* notes will be used and the beginner notes will be compared to these. It should also be noted that the recordings were all made in the same studio, using the same microphones as well as the same violin and bow.

2. FEATURE EXTRACTION

Features can be considered as descriptors and standard features include pitch, its variance, spectral centroid, zero-crossing rates, mean acoustic energy, onset, offset times to name but a few. In [3, 4], many features have been determined. Many of these features may be of use in this timbre task. The following section will consider quantitative features which represent effectively the quality of the sound within a same timbre.

2.1. Useful Features

Many features, although very useful in determining one instrument from another, are not appropriate for understanding the discrepancies due to playing technique. Pitch related or dependent features are of limited use within the context of bowing. Considering the shapes of the good player waveforms compared to those of the beginner player prompted looking at a statistical approach. Four orders of statistics were looked at and the mean and kurtosis proved to be the most informative and applicable for building a classifier. All four orders were applied to both time and frequency domains. Variance provided information supporting what a trained listener would say about a beginner sound compared to a good violin sound. As a player's technique becomes more secure, a better sound is produced which is more consistent or 'tighter', reducing the variance, see fig. 2.a., where the beginner files are represented by the dotted line. These results refer to variance in the time domain and are not ideal for use in a classifier.

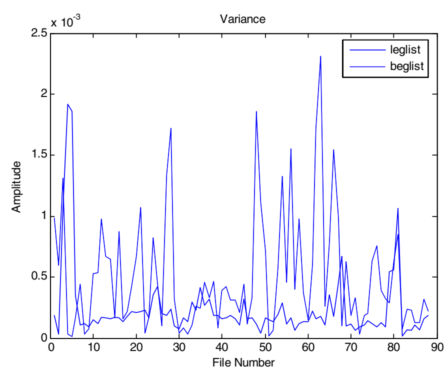

Figure 2.a: Variance readings for beginner and legato notes.

Skewness is a measure of symmetry in the data and was expected to return useful results, given the asymmetry present in the beginner files. However, kurtosis has proven to be a much more useful measure.

2.1.1. Mean

The mean or average in the time domain is much more useful than in the frequency domain as the latter contains pitch related information. The figures 2.b and 2.c below show the mean values for 88 different legato files and 88 beginner files. Figure 2.c displays a scatter plot of the same information. Both these figures show a significant gap between the mean values for the beginner and good legato notes.

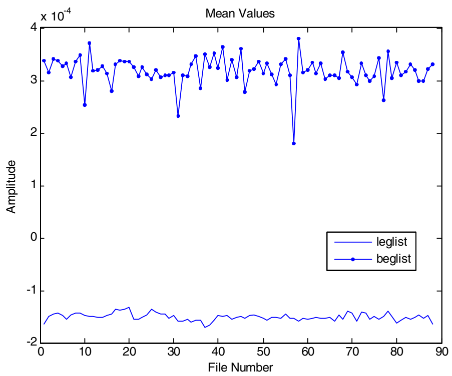

Figure 2.b: Plot of mean values of legato sounds (bottom line) and beginner sounds (top line).

The clear grouping of the two classes of files makes the use of a classifier unnecessary as the same results can be obtained through a computationally lighter approach. The beginner sounds are all grouped together in the upper right hand corner and the legato good sounds are in the bottom left hand corner. The size of the groups should be noted.

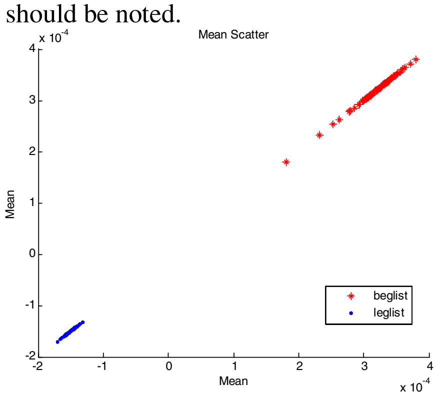

Figure 2.c: Scatter plot.

This gap can be explained by amount of bow pressure used by the player. This can be shown with recordings of a good player deliberately forcing the sound and crunching and can be seen in figure 2.e below where it is compared with legato as well as beginner notes.

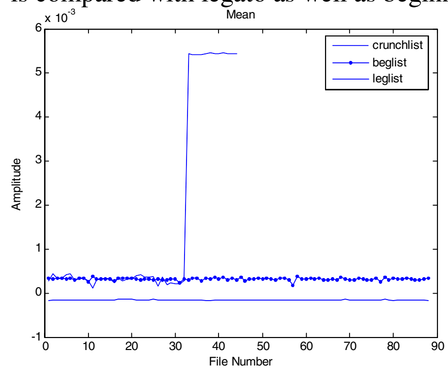

Figure 2.d: Effect of forced crunch on mean.

The large jump visible in figure 2.d is due to a trained violinist forcing and crunching. This is an extreme example included to explore the relationship between mean and bow pressure and smoothness of sound. Mean can be used as an indicator of bow pressure. However, a high mean value does not necessarily imply poor sound quality. The smoother the bow stroke, the lower the mean as can be shown by the legato sounds in figure 2.d. This is where type of bow stroke is of great importance. Bow stroke includes information about bow pressure and speed. Taking this further, the effect of changing the bowing direction on the reading cannot be dismissed. Unlike kurtosis, bow changes do not have a noticeable effect on mean. The mean value remains close to that of the notes on either side of the bow change. This is shown in figure below, where comparative files contain the same notes. Mleglist refers to the mean of good player legato sounds, mbc is the bow change mean, and k is for kurtosis.

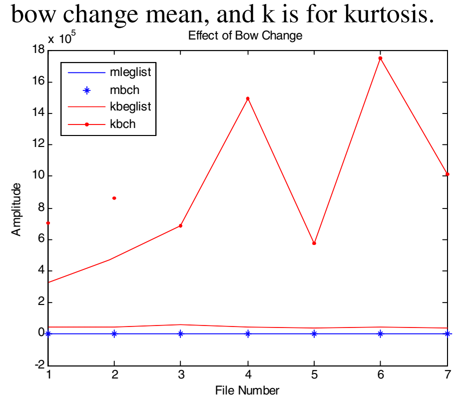

Figure 2.e: Effect of bow change on mean and kurtosis readings.

Ultimately, feature extraction should be triggered by onset detection. This way, unnecessary information for the task at hand can be omitted and cannot distort any readings obtained. The authors are not aware of the existence of a suitable onset detection system for the violin. The difficulty in developing such a detection system is in allowing for the variability in bow stroke or attack.

2.1.2. Kurtosis

Kurtosis results are shown in figure 2.f. The two groups of files each form well defined regions. What is of interest though, are the areas where overlapping occurs. Of the 88 files, 7 beginner player files overlap. Although some crunching and other bow faults are present, the sound is stronger and more committed compared with the other beginner files. These are better quality beginner sounds.

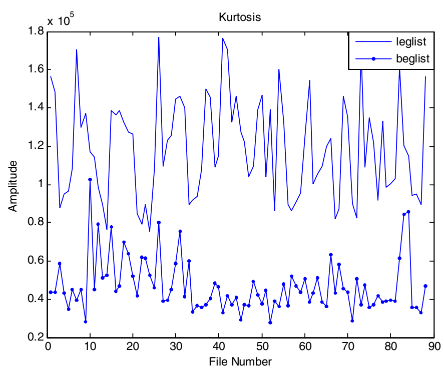

Figure 2.f: Kurtosis readings

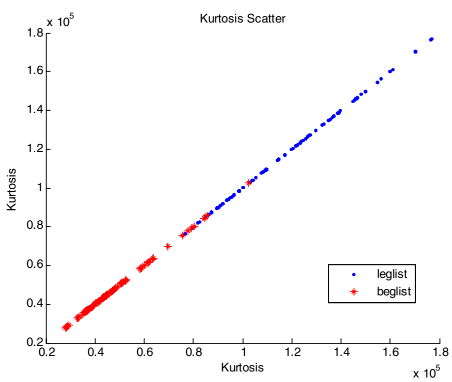

Figure 2.g: Scatter plot showing kurtosis values

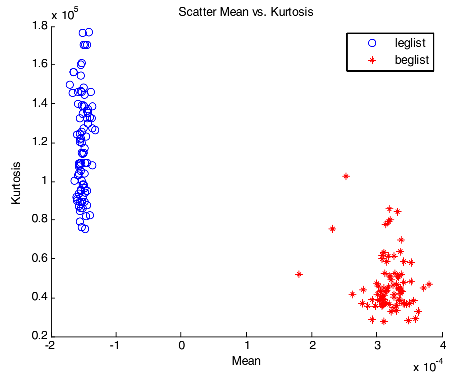

Figure 2.h: Scatter plot mean vs. kurtosis.

Figure 2.h is a scatter plot of mean versus kurtosis for both good player and beginner player files. The circles grouped together on the left side of the figure are the legato good player sounds and clump of asterisks to the right represent the beginner sounds. Two very distinct regions are present.

3. CONCLUSIONS AND FURTHER DEVELOPMENTS

Dealing with real instrument sounds, especially those produced by a violin, no feature is clearly defined nor is it independent. Much work still remains to be done in the area understanding feature interdependence. As shown in above figures, statistics have provided a straight forward yet effective result in getting a computer to identify beginner sounds from good legato notes. More work will be carried out in order to be able to fault detect with greater precision after which, sounds will be classified accordingly. This will then be incorporated into the violin teaching tool.

4. ACKNOWLEDGEMENTS

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